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One of the major thrusts of the transportation programs at the Oak Ridge National Laboratory has been the development of a number of computerized transportation programs and data bases. The U.S. Department of Energy (DOE) is supporting these efforts through the Transportation Technology Center at Sandia National Laboratories and the Transportation Operations and Traffic Management (TOTM) organization at DOE Headquarters. Initially this project was centered upon research activities. However since these tools provide traffic managers and key personnel involved in preshipment planning with a unique resource for ensuring that the movement of radioactive materials can be properly accomplished, additional interest and support is coming from the operational side of DOE.

The major accomplishments include the development of two routing models (one for rail shipments and the other for highway shipments), an emergency response assistance program, and two data bases containing pertinent legislative and regulatory information. This paper discusses the most recent advances in, and additions to, these computerized techniques and provides examples of how they are used.

INTERLINE

INTERLINE[1] is an interactive program designed to simulate routing practices on the U.S. rail system. Because the rail industry is divided into a large number of independent competing companies, INTERLINE decomposes the U.S. rail network into 95 separate subnetworks. Routing within each subnetwork is conducted independently in order to replicate the routing practices of an individual company.

The data base used by INTERLINE was originally obtained from the Federal Railroad Administration, and reflected 1974 data. It has consequently been extensively modified to reflect corporate mergers, correct errors, reflect line abandonments, incorporate new construction, and include line classification changes as railroads have modified and rationalized their routing practices since 1974. Figure 1 illustrates the current network, where thick lines indicate main lines which the railroads are more likely to use.

An important element of the data base is the transfer file, indicating where traffic may move from one subnetwork to another. Because transfers between railroads involve additional cost and delay, penalties are assigned to these movements to replicate the tendency of traffic to remain on a single railroad's lines when possible.

Algorithmically, the model uses a label-setting routine to find minimum impedance paths within a subnetwork embedded in a label-correcting routine to find paths among subnetworks. An additional benefit of this decomposition approach is that computer resource requirements are reduced, allowing INTERLINE to run as an interactive program despite the large size of the network (approximately 17,000 links).

The user has the option of specifying a number of parameters in the routing, although defaults are provided which represent typical practices in the industry. By varying the parameters the user can find alternative routes, examine the effect of restricting movement through specified areas, such as specific cities or specific railroad systems. Another important capability is the estimation of short-line

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mileages between points, which are distances that disregard the effects of competition among carriers, and which are the basis of freight rate calculations using class tariffs.

Printed descriptions of routes are provided to the user at a terminal. A map of the route may also be produced, either at the terminal or off-line, allowing the user to more quickly understand the implications of different scenarios or routing policies. A typical route map is shown in Fig. 2 for two possible routes from Richland, WA, to Barnwell, SC. The actual route used will depend on negotiations between the railroads and the traffic manager responsible for the particular shipment.

HIGHWAY

The HIGHWAY[2,3] program provides a flexible tool for predicting highway routes for transporting radioactive materials in the United States. The HIGHWAY data base is essentially a computerized road atlas that currently describes over 240,000 miles of highways. A complete description of the Interstate highway system and all U.S. highways (except those that parallel a nearby Interstate highway) is included in the data base. Most of the principal state highways and a number of local and county highways are also identified. Recent additions to the data base include nuclear facilities and major airports.

Several different types of routes may be calculated depending upon a set of user supplied constraints. Routes are calculated by minimizing the total impedance between the origin and the destination. Basically, the impedance is defined as a function of distance and driving time along a particular highway segment. Several routing constraints can be imposed during the calculations. Frequently, routes are needed which bypass major population areas. A special data base has been added to the HIGHWAY model which deletes all highway segments located within urbanized areas containing over 100,000 people. Routes generated from this data base will not utilize any roads in these urbanized areas. Other commonly used constraints include the ability to calculate routes which maximize the use of the Interstate highway system, routes which bypass a specific state, city, town, or a specific highway segment.

The output generated by the HIGHWAY program includes a brief summary showing the origin, destination, departure and arrival times, estimated driving time, and total distance. The mileage driven in each state is also listed, along with the mileage traveled in the various highway types. A more detailed route description is also available where each individual highway is identified along with the points where the route enters and leaves the highway.

An example of the various routing options is shown in Figs. 3 and 4. A route between the Turkey Point reactor south of Florida City, FL, and the Nevada Test Site, NV, is used in these examples. Three different routes are shown in Fig.3. The solid line represents the most direct route. The dashed line shows the route which would be used for the shipment of spent fuel which must bypass a legislative restriction in Louisiana. The third route follows the interstate highways exclusively. An example of predicting a route which bypasses all major urbanized areas is shown in Fig. 4.

AIRPORT

The AIRPORT[4] locator program was developed to rapidly provide emergency response information for the DOE in responding to incidents which may involve radioactive materials. The program includes a data base listing approximately 800 commercial and military airports in the continental U.S. that could be used in transporting specialized equipment and/or personnel to a particular site. The data base includes a description of the major runways at each airport including information on geographic coordinates, length, width, runway surface, runway weight-bearing capacity, and instrument approach capabilities.

The AIRPORT locator program is designed to find all the airports in the vicinity of a predetermined location. The central position used for the search is a highway intersection derived from the HIGHWAY model. The airport locator program establishes a search window centered at this location, with approximate dimensions of 300 x 300 miles; all airports within the window that meet specified criteria are extracted from the data base. The line-of-flight distance between the airports and the central point is calculated, and the airports are listed in order of their distance from the center.

If desired, several constraints specifying airport capabilities can be included, and only the airports which satisfy these constraints will be reported. If no constraints are imposed, all airports within the window are considered. The user-specified constraints include minimum runway length, instrument approach capability, and aircraft landing weight.

An example of two different airport searches is shown in Figs. 5 and 6. The central point for each search is Russelville, AR. In the first example (Fig. 5), no specific airport capabilities were specified and the ten airports closest to Russelville are shown. The second example, only the airports capable of handling C-5 aircraft are shown.

THE LEGISLATIVE AND REGULATORY INFORMATION SYSTEM

The Legislative and Regulatory Information System (LRIS), at Oak Ridge National Laboratory, operates as a computerized data base for gathering and disseminating legislative-type information which could affect the transportation of radioactive/hazardous materials. State and local governments have expressed their concern through the adoption of specific transportation restrictions, e.g., requests that notifications be made prior to shipment, requirements for special permits and escorts, and completely banning shipments through certain cities, specific bridges, tunnels, and toll roads. The information contained in the LRIS has been organized into two specialized interrelated files, i.e., the Legislative Data Base and the Operational Restrictions and Emergency Response Contacts Data Base, which function as a unit. Data storage, information retrieval, and data base maintenance are handled through the INQUIRE data management system.

Legislative Data Base

One component of the LRIS, the Legislative Data Base[5-7], functions as a comprehensive information file that contains detailed data on federal-, state-, local-, and operational-level legislative and regulatory actions affecting the transportation of radioactive/hazardous materials. The data base consists of about 2500 entries that have been abstracted and indexed into a specialized format. Thus, a user can easily identify specific restrictions in a particular state of interest. For example, permits required in the state of Iowa for shipping spent fuel or specific highways, bridges, and tunnels which have been banned from radioactive materials transportation can easily be extracted. A sample record from the Legislative Data Base is shown in Fig. 7. This particular bill summarizes a law in the state of Virginia which requires a five-day prior notice (including route) for the shipment of hazardous radioactive material.

Directory of Operational Restrictions and Emergency Response Contacts

A second component of the LRIS that operates as a supporting tool to the overall program is an on-line directory which highlights those operational restrictions that prohibit or restrict the use of specific highways, rail lines, bridges, tunnels, and toll roads. The Operational Restrictions and Emergency Response (ORER) Contacts Directory Data Base[8,9] identifies the key state, county or local contact agency/person responsible for the transportation of radioactive/hazardous materials through a particular jurisdiction. Also included are emergency assistance contacts for each state. A list of major emergency telephone numbers, any of which can be called on a 24-h basis, is provided for each type of material involved, e.g., hazardous or radioactive materials.

Approximately 1000 entries covering all states are currently in the directory. The collected information is organized to permit quick access to key contacts in a precise area of concern. Traffic managers can utilize the ORER Data Base during their preshipment planning to quickly determine any impediments along a particular route. In the case of an emergency incident involving either radioactive or hazardous materials, emergency response personnel can instantly identify the key state or local officials to be contacted for the specific type of material involved.

A sample record from the ORER Data Base is shown in Fig. 8. This record identifies the fact that radioactive materials are banned from the Pennsylvania Turnpike.

Development is underway to interface the LRIS with the HIGHWAY and INTERLINE routing programs at ORNL. The transportation restrictions identified in the LRIS are currently being incorporated into the HIGHWAY Data Base. Knowledge gained through the interface of these programs will provide a unique tool in preshipment planning.

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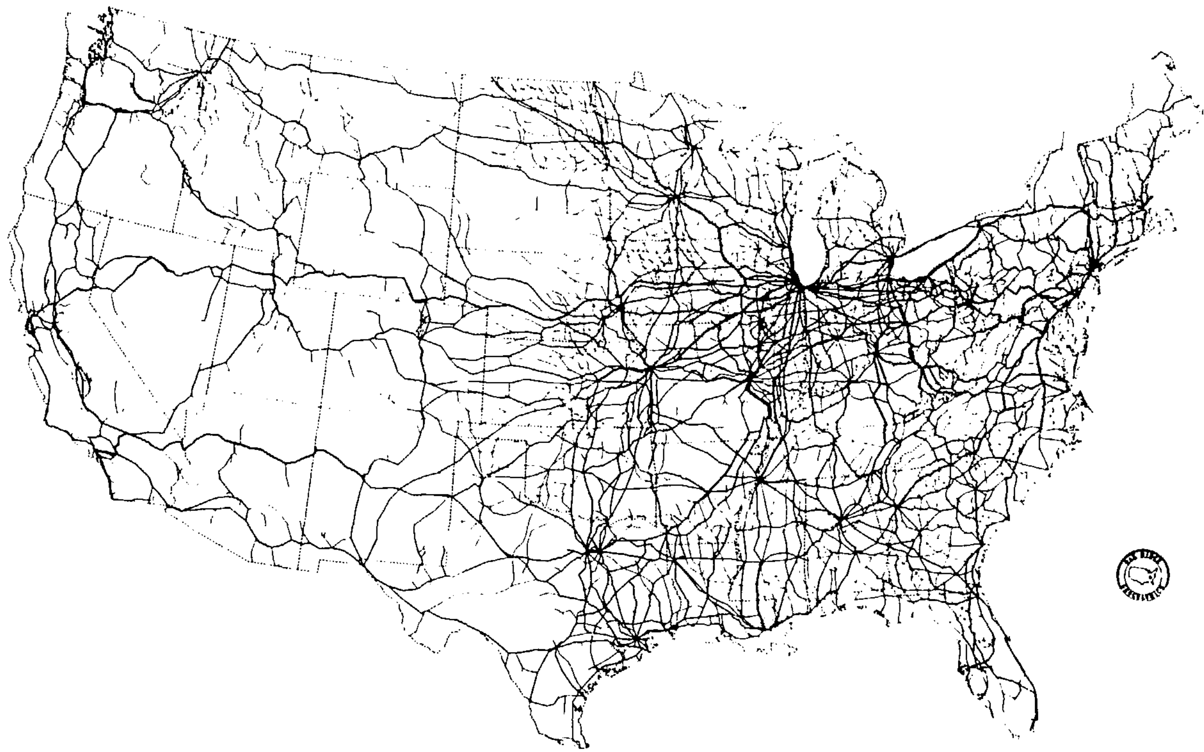
U.S. RAILROAD SYSTEM
ORNL NETWORK 5



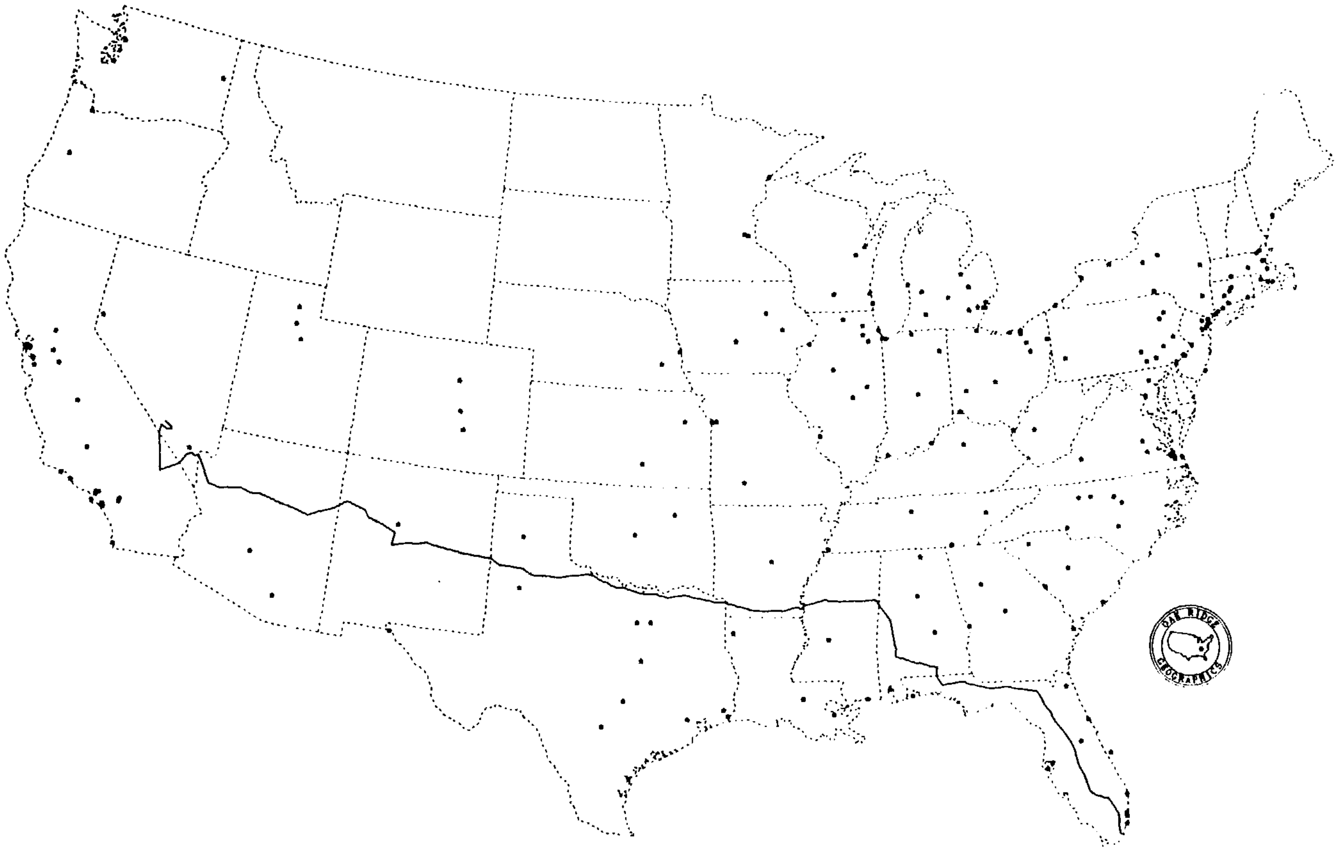
TYPICAL RAIL ROUTE
FROM RICHLAND, WA TO BARNWELL, SC

ORNL-DWG 83-7876

PREDICTED TRUCK ROUTE FROM SOUTHERN FLORIDA TO SOUTHERN NEVADA
GENERAL ROUTE – SOLID LINE
BYPASSES LOUISIANA – SHORT DASH LINE   INTERSTATE ROUTE – LONG DASH LINE

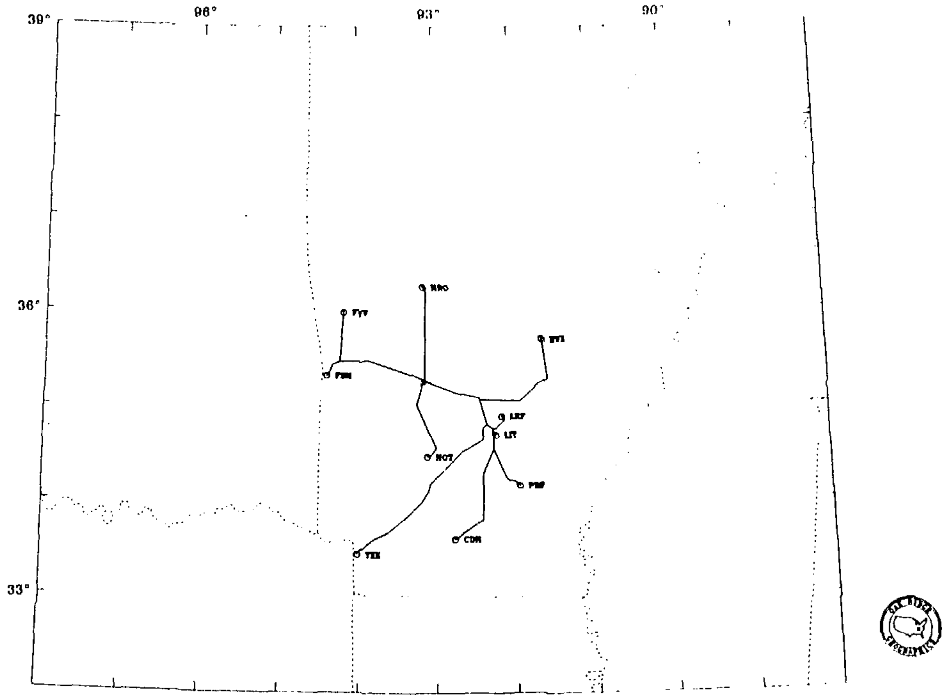
ORNL-DWG 83-7870

PREDICTED TRUCK ROUTE FROM SOUTHERN FLORIDA TO SOUTHERN NEVADA
BYPASSING LOUISIANA AND METROPOLITAN AREAS OVER 100,000



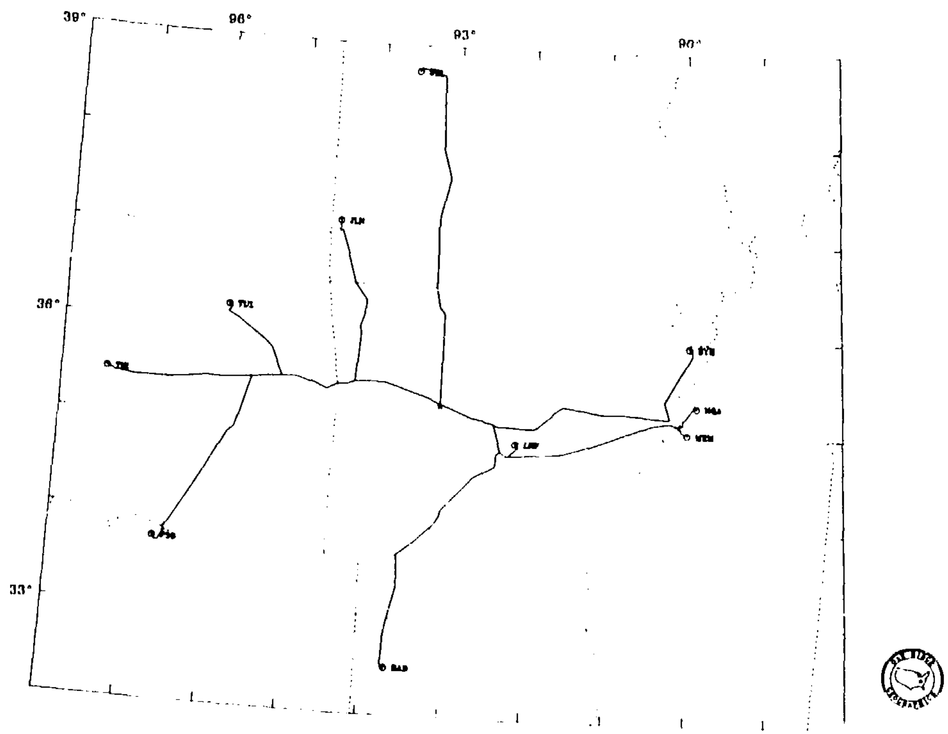
ORNL-DWG 83-7842

NEAREST COMMERCIAL AND MILITARY AIRPORTS TO RUSSELLVILLE, AR



NEAREST COMMERCIAL AND MILITARY AIRPORTS TO RUSSELLVILLE, AR WITH C5 AIRCRAFT LANDING CAPABILITY

ORNL-DWG 83-7813



STATE		Virginia
LOCALE		State of Virginia
BILL NUMBER	(1)	VA-H0191F
TITLE		Chapter 33, Transportation of Hazardous Radioactive Materials
CURRENT STATUS	(1)	Required 03/27/79
HISTORICAL STATUS	(1)	Introduced 01/22/79
	(2)	Committee (General Laws), Date Unknown
SPONSOR		Grayson; Diamonstein; Scott, K.C.; Dickinson; Murray, Michie
LEGISLATION TYPE		State
REFERENCE REPORT		None
SOURCE		Bill; NRC State Program Report dtd. 3/23/79; GA Newsletter dtd. 6/19/79; DOE-ORO Trans. Br. Chief
CATEGORY	(1)	Notify
MODE		Truck
REGION		SE, 2
KEYWORDS	(1)	RADIOACTIVE MATERIALS
	(2)	NOTIFICATION
	(3)	PROHIBIT TRANSPORTATION
	(4)	HEALTH DEPARTMENT
	(5)	HAZARDOUS MATERIALS
	(6)	DEFINITIONS
	(7)	EMERGENCY SERVICES OFFICE
	(8)	ROUTES
COMMENTS		Bill provides for defining of hazardous radioactive materials, require 5 days prior notification (including proposed route), provides for approval of plans, and provides for notification of local officials along route. Directs the Office of Emergency Services to monitor the transportation of radioactive materials within the state. Approval would be supplied by the coordinator of the Office of Emergency Services
ABSTRACT		The Coordinator of the Office of Emergency Services (COES), by July 31, 1979, in conjunction with the Commissioner of the Virginia Department of Health, shall define and make public a list of those hazardous radioactive materials, the transportation of which may constitute a significant protential danger to the citizens of the Commonwealth of Virginia in the event of accidental spillage or release. No person shall transport, or cause to be transported, into, through, or within the Commonwealth of Virginia any hazardous radioactive materials as defined by the COES pursuant to 44-146.30 of this chapter unless such person has notified the COES no later than five days before the transport of such materials. Such notice shall include (1) the route proposed to be taken, (2) the proposed time of transportation, (3) the material to be transported, (4) the method of the proposed transportation, and (5) any additional information that may be required by the COES. The COES shall approve, disapprove or approve with conditions, any plans to transport hazardous radioactive materials and shall notify the person submitting such plan of its approval, disapproval or conditional approval, no later than forty-eight hours before the proposed time of transport. The COES, as soon as practical after approval of plans to transport hazardous radioactive material, and no later than twenty-four hours before the time of such transport begins, shall notify the appropriate official in such political subdivision through which such shipment shall pass of the route, time, and nature of the hazardous material to be transported. The Board of Health will promulgate rules and regulations governing the transportation of radioactive materials by January 1, 1980

Fig. 1. Legislative Data Base sample record.

STATE		Pennsylvania
LOCALE		Pennsylvania Turnpike
LEGISLATION TYPE		Operational
CATEGORY	(1)	Prohibit
NAME		Clarence Wright, Safety Director
STREET		Administration Building, Highspire, P. O. Box 8531
CITY		Harrisburg
STATE CODE		PA
ZIPCODE		17105
PHONE		717/939-9551, ext. 222
EMERGENCY NO.		800/932-0586
COMMENTS		Shipments of radioactive materials are banned from Pennsylvania Turnpike, must route around; combustibles, fuel oil, and non-flammable gas are allowed with permits through Permit Section.
KEYWORDS	(1)	PROHIBIT TRANSPORTATION
	(2)	RADIOACTIVE MATERIALS
	(3)	PERMITS
	(4)	HAZARDOUS MATERIALS
REFERENCE MATERIALS	(1)	Pennsylvania Turnpike Map
CORRESPONDENCE		Phone call 8/82

Fig. 2. OHER Data Base sample record.